The

Kentucky Geological Survey

WILLARD ROUSE JILLSON
DIRECTOR AND STATE GEOLOGIST

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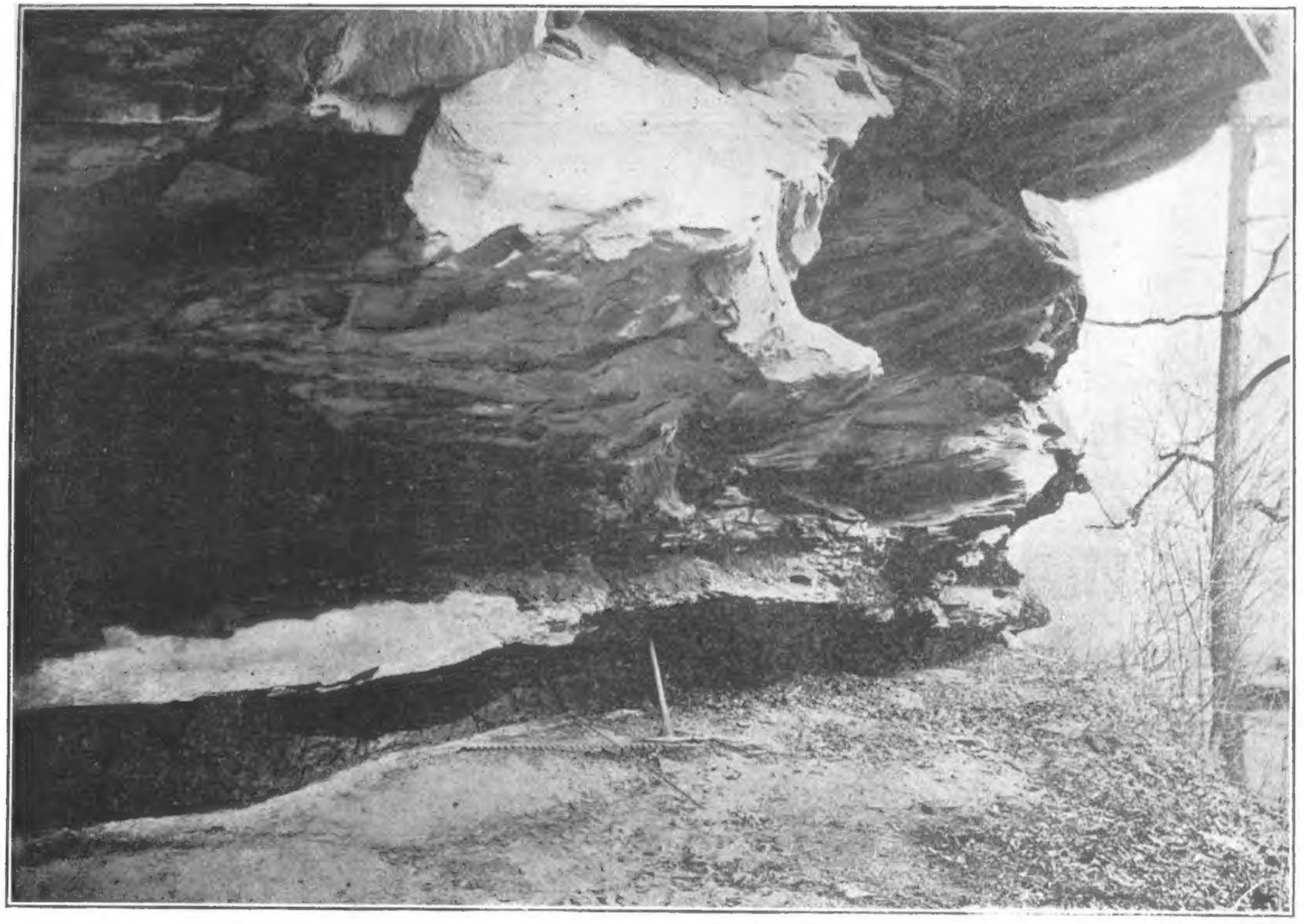

THE WHITESBURG COAL AND SANDSTONE "ROCKHOUSE" ROOF.

This characteristic view of the well known Whitesburg coal and its superimposed thirty feet of cliff forming sandstone may be seen on Otter Creek just above its juncture with the Middle Fork of the Kentucky River in Perry County.

THE
SIXTH GEOLOGICAL SURVEY

An Administrative Report of the Several Mineral Resource and General Geological Investigations Undertaken and Completed in Kentucky during the Biennial Period 1920-1921

By

WILLARD ROUSE JILLSON
DIRECTOR AND STATE GEOLOGIST

PRESENTED WITH TEN SEPARATE MISCELLANEOUS GEOLOGICAL PAPERS

BY

GEORGE P. MERRILL,
STUART WELLER
WILLARD ROUSE JILLSON
STUART ST. CLAIR
AND
CHARLES STEVENS CROUSE

Illustrated with 101 Photographs Maps and Diagrams

First Edition

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PREFACE

Applied geology is of great economic value to every State in which natural resources are only partly developed. This is especially true of Kentucky where the great body of mineral resources are now less than 20% under commercial operation. An ideal arrangement would be one where the State would have completed the base (topographic) mapping and the preliminary geological-resource surveys prior to the opening up of any oil, coal, natural gas, asphalt or other field. During the period of proving up such a field, State employed geologists could well work hand in hand with the operators, and assist them greatly in their efforts to win the resources desired.

Unfortunately this ideal arrangement has never existed in Kentucky, though it has to some extent in other States. With only 46% of Kentucky base (topographic) mapped, and with an area approximating that of sixty counties not covered by any accurate maps at all, the function of the Kentucky Geological Survey has always been crippled and held in restraint. The day of a 100% efficiency of the Kentucky Geological Survey seems yet to be in the distant future.

During the last biennium a large number of subjects of great economic value to this State have been investigated, however, by the Kentucky Geological Survey. A full account of these investigations is presented herewith in the first paper of this volume entitled, "The Sixth Geological Survey." A number of these economic papers are included within the covers of this book, and should assist materially in an understanding of the geology and resources of the several regions covered. This report is issued in an original edition of one thousand copies.

W. R. Jillson

Director and State Geologist.

Old Capitol,
Frankfort, Kentucky.
December 15, 1921.

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OIL AND GAS POSSIBILITIES IN CALDWELL COUNTY, KENTUCKY.

By Stuart Weller,

Assistant Geologist.

INTRODUCTION.

During the progress of the detailed mapping of the geology in the Princeton, Kentucky Quadrangle of the U. S. Geological Survey atlas sheet, in the summer of 1921, the greater portion of which falls within Caldwell County, an area which may possibly be productive of oil and gas has been discovered. At the present time there is no oil or gas production in the County; a few wells have been drilled, one of which, a dry hole, has just been completed to a depth of 2,000 feet at Cedar Hill, two and one-half miles southeast of Princeton. A number of wells have been drilled in the past, one or two of which are reputed to have shown a trace of oil, but no definite record of them can be secured at this time.

THE FARMERSVILLE DOME.

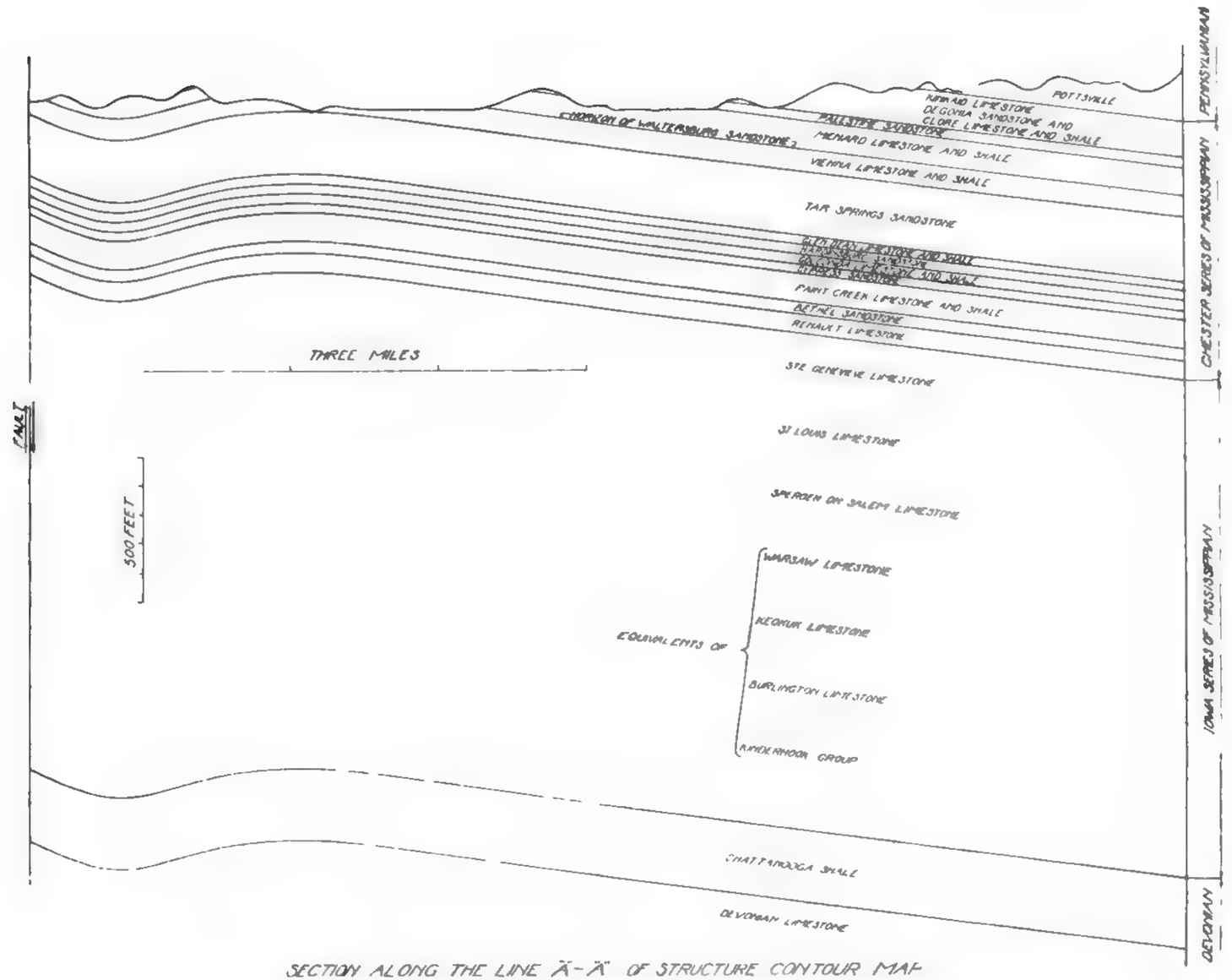
The greater portion of the area mapped is very complexly faulted and the conditions are such that the probability of any oil accumulation is very remote. West of Farmersville, however, six and one-half miles north of Princeton, there is an unfaulted area in which a distinct structural dome is present, which may be considered as a possible source of oil or gas production. It is not possible to predict the result of drilling in this dome because it is so far removed from any productive area, but if any wild cat development should be contemplated in the region, it would be wisest to place the wells at points where the structural conditions are the most favorable.

STRATIGRAPHY.

The rocks exposed at the surface about Farmersville are all members of the Chester Series of Upper Mississippian age. The lowest formation actually exposed at the surface within the area of the Farmersville dome is the Vienna limestone and shale. This formation is characterized by shale beds in its upper portion, which constitute one-half or more of the entire formation. The lower portion consists of limestone and shale layers interbedded. The limestone is particularly characterized by the large amount of flint or chert which it contains, commonly in the form of bands from one to three inches in thickness, lying essentially horizontal, parallel with the bedding. Where this cherty limestone has been subjected to long weathering the calcareous portion of the bed has been removed by solution, and the chert or flint remains with the residual clay. Flinty, residual beds of this sort are well exhibited about Farmersville, along the public highways north and west of the village.

At Farmersville a thin sandstone overlying the Vienna is exposed at an elevation between 480 and 500 feet above sea-level. This is the Waltersburg sandstone of the section, and probably does not exceed twenty feet in thickness anywhere in the area, and in places it is ten feet or less thick. This formation is exposed at a number of points along the public highways which radiate from Farmersville, and the difference in elevation of the outcrops of the sandstone serve to outline the dome structure centering a little west of Farmersville.

Overlying the Waltersburg sandstone, and well exposed about the dome and in many of the hills within the area where the Waltersburg and Vienna are present in the valleys, is the Menard limestone. This formation attains a thickness of 140 feet. In its lower portion it contains much calcareous shale with thinly bedded limestones, and some more compact limestone beds. The higher portion of the formation contains much more limestone, much of which is compact in texture, hard and brittle, breaking with a splintery fracture. The limestone beds of the formation are from one to two or more feet in thickness, being separated by shales which may be only shaly partings, or may be shale beds up to several feet thick.



SECTION ALONG THE LINE Ä-Ä' OF STRUCTURE CONTOUR MAP

Dingramatic Section Showing Structure of the Farmersville Dome.

The highest formation exposed within the dome area is the Palestine sandstone. This is a more or less massive, yellowish-brown to pink sandstone, of rather fine texture, which attains a maximum thickness of about 60 feet. In places it includes some sandy shale beds, but the more massive layers are most often well exposed. The sandstone is present capping the hills which lie around the borders of the dome, becoming a more continuous formation farther east, the dip of the beds finally carrying it beneath the higher formations of the Chester Series, and these in turn pass beneath the Pottsville beds of the Pennsylvanian.

POSSIBLE OIL AND GAS "SANDS."

The unexposed formations of Chester age within the limits of the dome, lying beneath the Vienna limestone, are (1) the Tar Springs sandstone, an alternating series of more or less massive sandstones and sandy shales, 200 feet or more in thickness, (2) the Glen Dean limestone, mostly shales, with a massive limestone bed ten feet thick at its base, the whole thickness of the formation being about 40 feet, (3) the Hardinsburg sandstone, for the most part a sandy shale with thin sandstone layers, the whole being about 30 feet thick. (4) The Golconda limestone, mostly calcareous shales with thin limestone layers, about 40 feet thick. (5) The Cypress sandstone, a thinly bedded sandstone formation about 30 feet thick. (6) The Paint Creek formation, an alternating series of hard limestone beds, some of which are oolitic, with shale partings, some of which may be several feet in thickness, the whole formation being about 100 feet. (7) The Bethel sandstone, a massive, fine-grained, yellowish-brown sandstone about 40 feet thick. (8) The Renault limestone, consisting of layers of hard blue to gray limestones with shale partings, the whole being about 80 feet thick. Beneath the Renault formation there is a great series of Lower Mississippian limestones (10), including from above downward, the Ste. Genevieve, the St. Louis, and the equivalents of the Spergen or Salem, the Warsaw, the Keokuk, the Burlington limestones, and the Kinderhook Group. This series is as much as 1,700 feet thick in the recently drilled well at Cedar Hill. There is likely to be a thin sandstone member from five to fifteen feet thick somewhere within 50 feet of the top. The lower

500 feet of this series of beds may be expected to be nearly black, hard, silico-calcareous shales, or an impure siliceous limestone, as in the Cedar Hill well. Beneath these Lower Mississippian limestones is the Chattanooga shale (11), a black, more or less fissile shale, 242 feet thick at Cedar Hill. Underlying the Chattanooga shale is a light colored, highly crystalline limestone (12), in the Cedar Hill well. This limestone is doubtless of Middle Devonian age.

STRUCTURE AND DRILLING LOCATIONS.

In the accompanying structure map it will be observed that the dome lies between faults to the north, south, and west, but no dislocation has been detected to the east and northeast, from which direction the oil, if present, would presumably have been accumulated. In order to test the structure a desirable location in approximately the center of the dome, is in the valley of a tributary of Donaldson Creek from the west, about one and one-fourth miles west of Farmersville. Other tests might be made upon the northeastern flank of the structure, in a general easterly direction through Farmersville to the valley of Caney Creek in the vicinity of Briarfield Church.

In this connection it should be stated that an igneous dike has been recognized at a point 1.1 miles southeast of Briarfield Church, and 1.9 miles southeast of Farmersville, the location of this dike being indicated by x on the map. The direction and extent of the dike is not known, but it would probably be unwise to prosecute the search for oil in the immediate vicinity of the dike.

The accompanying diagramatic cross-section of the Farmersville dome gives a clear idea of the strata which would be penetrated in drilling. The thicknesses of the several strata shown for the Chester Series are those which have been observed in surface outcrops within the Princeton Quadrangle, those for the beds beneath the Chester Series are taken from the data afforded by the recently drilled well at Cedar Hill. The section at the center of the dome would be as follows:

MAP
OF THE
STRUCTURAL GEOLOGY
OF THE
FARMERSVILLE DOME
IN CALDWELL CO., KENTUCKY
BY
STUART WELLER
ASST GEOLOGIST
KENTUCKY GEOLOGICAL SURVEY
WILLARD ROUSE JILLSON
DIRECTOR AND STATE GEOLOGIST

1921
U.S.G.S. BASE
SCALE REDUCED FROM
1-62500.
KEYBED - WALTERSBURG SANDSTONE

Sketch Map of Farmersville Dome, Caldwell Co., Ky.

Chester Series.

MISSISSIPPIAN SYSTEM.

	Thickness feet	Depth feet
Tar Springs formation, sandstone and sandy shales	200	200
Glen Park formation, shales and limestones	40	240
Hardinsburg formation, sandstone and sandy shales	30	270
Golconda formation, shales and limestone	40	310
Cypress sandstone	30	340
Paint Creek limestone and shale	100	440
Bethel sandstone	40	480
Renault limestone	80	560
Iowa Series (Lower Mississippian)		
Ste. Genevieve limestone	300	860
St. Louis limestone	350	1,210
Equivalents of Spergen, Warsaw, Keokuk, Burlington and Kinderkook formations	1,050	2,260
DEVONIAN SYSTEM.		
Chattanooga black shale	240	2,500
Middle Devonian limestone	?	?

SUMMARY OF DRILLING.

The possible oil and gas horizons in the Farmersville dome are the Cypress and Bethel sandstones at depths of 310 and 440 feet respectively, at the center of the dome. If nothing should be found in these sands drilling would probably have to be continued through to the top of Chattanooga black shale to reach the shallow "sands" of Warren County. The Middle Devonian limestones, from which the greater part of the oil production in southern Kentucky is obtained will be found just below the black shale. Still deeper production might be sought in strata of Silurian and Ordovician age, but the area is so far removed from localities where surface outcrops of these formations are exposed, that any prediction of their depth would be extremely hazardous. The estimated thicknesses of the formations given in the foregoing table are of course subject to some error, and it is possible that the distance to the base of the Chattanooga shale may be more or less than is suggested, with a possible error of 100 to 200 feet.

CEDAR HILL WELL.

A stratigraphic interpretation of the 2,000 foot dry hole at Cedar Hill is important in connection with any further oil and gas prospecting of this or the Farmersville region. Drill cutting samples from the Cedar Hill well have been generously furnished to the writer by Mr. F. K. Wylie of Princeton for laboratory examination and identification. Surficial examinations made in the field establish the fact that this well starts in the Ste. Genevieve limestone, about 70 feet below the contact between this formation and the overlying Renault limestone which is exhibited in the Cedar Hill quarry, one-half mile northeast of the well. The contact is at an elevation of 550 feet above sea level, and the top of the well is approximately 490 feet. The difference between these two elevations is 60 feet, but the slight dip of the strata to the northeast would somewhat increase the interval at the well, to approximately 70 feet. The Chattanooga shale was penetrated at a depth of 1,630 feet. This depth, added to the 70 feet of Ste. Genevieve limestone not represented in the well section gives a total thickness of 1,700 feet for the Lower Mississippian or Iowa Series.

The nearest Lower Mississippian section which has been studied carefully is that of Hardin County, Illinois (1), where a total thickness of the equivalent beds is estimated to be 1,450 feet. At no locality in Hardin County, however, is the complete section exposed, and the thickness of some of the members has been estimated from scattered surface outcrops, and some of the estimates may be too low. In the Hardin County section the beds are divided as follows:

Ste. Genevieve limestone	300 feet
St. Louis limestone	350 feet
Warsaw (including Spergen) limestone	250 feet
Osage limestones	550 feet

No lines of sharp demarkation have been recognized in the Hardin County section, between any of the formations, and they doubtless represent a continuous, uninterrupted sequence of sediments.

The cuttings from the Cedar Hill well which have been available for study are not complete, the first sample being from a depth of 250-255 feet. From the depth of 310 feet to the bot-

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(1) Ill. State Geol. Surv., Bull. No. 41, pp. 91-120 (1921).

tom of the well a continuous series of cuttings has been saved, although a sample was not taken from each screw, but in general only when the driller recognized some change in the rock, there being 56 samples in all. There is no sample from limestone of Ste. Genevieve age, at least there are no cuttings showing any oolitic structure, which would be expected in the Ste. Genevieve. If a maximum thickness of 300 feet of this formation is present, as is indicated in Hardin County, Illinois, the bottom of the Ste. Genevieve in the well should be at a depth of 230 feet, and the first cuttings are at 250-255. These first cuttings are of a character that might well be expected in the St. Louis limestone, situated next beneath the Ste. Genevieve, and all of the cuttings studied, down to the depth of 550 feet are of similar character; gray limestone, varying somewhat from dark gray to nearly white, with much chert, some samples being much more cherty than others. If 550 feet is the bottom of the St. Louis limestone then the formation is 320 feet thick, assuming 300 feet for the Ste. Genevieve. This compares favorably with the Hardin County section where an estimated thickness of 350 feet of St. Louis limestone is present.

The sample from the depth of 550 to 555 is a black rock which seems to be a hard shale with much calcium carbonate and silica. This silico-calcareous shale passes downward into more calcareous beds, the prevailing character to 800 feet being brown limestone, somewhat gray in some samples, with varying amounts of chert and some pyrite, some of the limestone is siliceous in addition to the included chert. From 800 to 1,000 feet the strata are limestone, but the beds are grayer in color than those above 800. Most of the samples contain fragments of chert, and some of them have considerable quantities of pyrite. From 1,000 to 1,100 feet the samples are brown limestone with chert and pyrite like those above, with some silico-calcareous shales below.

From 1,100 to 1,600 feet the samples are all a dark, mostly nearly black, silico-calcareous shale without chert. From 1,600 to 1,630 feet the samples become somewhat different. From 1,602 to 1,610 the sample is darker and more siliceous than those higher up. From 1,610 to 1,615 the same sort of material is shown with some lighter gray limestone. From 1,615 to 1,625

the sample is greenish-black in color and is practically without lime. The Chattanooga shale begins at 1,630.

In this Lower Mississippian section the limits of the recognized formations of the Mississippi valley are not determinable. The most noticeable line is at 1,100 feet, where the change from beds which are clearly limestone to the dark, silico-calcareous shale occurs. This lower division, from 1,100 to 1,630 may represent the Osage, although it is very different in lithologic character from the Burlington and Keokuk limestones of the Mississippi valley. No fragments of fossils whatever have been observed in any of these cuttings. The thickness of these beds, 530 feet, is comparable with the 550 feet of the Osage section in Hardin County, Illinois, where the beds are represented on the surface almost wholly by residual cherts. It is possible that originally the Hardin County sediments may have resembled the beds present in the Cedar Hill well.

The interval between the top of the presumably Osage sediments and the possible base of the St. Louis limestone, between the depths of 550 and 1,100, a total thickness of 550 feet, is more than twice the estimated thickness of the combined Warsaw and Spergen in Hardin County. Some portion of the upper part of this series of beds should perhaps be added to the St. Louis limestone, and some of the lower portion may belong in the Osage, but it doubtless does include the equivalents of the Warsaw and Spergen farther north.

The Chattanooga shale in the Cedar Hill well is 242 feet in thickness, which is considerably greater than has been observed in well logs in the producing oil fields of southern Kentucky, where it is 40 to 50 feet in Allen County, but in Hardin County, Illinois, there is an estimated thickness of 400 feet of the formation exposed in the Hicks dome. The lithologic character of this shale, as shown in the cuttings, is like that of the Chattanooga elsewhere. It is brown to black in color, and some of the fragments show the characteristic *Sporangites*. Some layers of the shale contain much pyrite, one sample from the depth of 1,835 feet being particularly full of pyrite fragments.

Beneath the Chattanooga shale, beginning at a depth of 1,872 feet, there is a very white, highly crystalline limestone. No fossils have been contained in any of the cuttings, but it is pre-

sumably a limestone of Middle Devonian age. The last sample examined at 1,882 feet is from this limestone, but it is known that the well has been drilled to a depth of 2,000 feet.

Description of Cedar Hill Well Log.

Iowa Series (Lower Mississippian)

	Thickness	Depth
No samples	250	250
Gray limestone, more or less crystalline, with chert	5	255
No samples	55	310
Dark and light gray limestone, more or less crystalline, with chert	240	550
Black, silico-calcareous shale	10	560
Dark silico-calcareous shale with some gray limestone	25	585
Brown limestone with chert and pyrite	65	650
Brown to gray limestone with chert and pyrite	30	680
Gray and brown limestone with chert and pyrite	350	1,030
Brown limestone with some silico-calcareous shale, some chert and pyrite	70	1,100
Dark to black silico-calcareous shale with some pyrite but no chert	502	1,602
Black, silico-calcareous shale, more silicious than that above	8	1,610
Black silico-calcareous shale with some gray limestone	5	1,615
Greenish-black, highly silicious shale	10	1,625
No sample	5	1,630
Chattanooga Shale (Devonian).		
Brown to black shale with Sporangites	135	1,765
Black shale with conspicuous pyrite bed at 1835	107	1,872
Middle Devonian Limestone		
White crystalline limestone	10	1,882
Total depth		1,882